National Institute of Environmental Health Sciences

Estimating the effects of increased urbanization on surface meteorology and ozone concentrations in the New York City metropolitan region

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Abstract:

Land use and pollutant emission changes can have significant impacts on air quality, regional climate, and human health. Here we describe a modeling study aimed at quantifying the potential effects of extensive changes in urban land cover in the New York City (NYC), USA metropolitan region on surface meteorology and ozone (O3) concentrations. The SLEUTH land-use change model was used to extrapolate urban land cover over this region from "present-day" (ca. 1990) conditions to a future year (ca. 2050), and these projections were subsequently integrated into meteorological and air quality simulations. The development of the future-year land-use scenario followed the narrative of the "A2" scenario described by the Intergovernmental Panel on Climate Change (IPCC), but was restricted to the greater NYC area. The modeling system consists of the Penn State/NCAR MM5 mesoscale meteorological model; the Sparse Matrix Operator Kernal Emissions processing system; and the US EPA Community Multiscale Air Quality model, and simulations were performed for two 18-day episodes, one near-past and one future. Our results suggest that extensive urban growth in the NYC metropolitan area has the potential to increase afternoon near-surface temperatures by more than 0.6 °C and planetary boundary layer (PBL) heights by more than 150 m, as well as decrease water vapor mixing ratio by more than 0.6 g kg-1, across the NYC metropolitan area, with the areal extent of all of these changes generally coinciding with the area of increased urbanization. On the other hand, the impacts of these land use changes on ozone concentrations are more complex. Simulation results indicate that future changes in urbanization, with emissions held constant, may lead to increases in episode-average O3 levels by about 1-5 ppb, and episode-maximum 8 h O3 levels by more than 6 ppb across much of the NYC area. However, spatial patterns of ozone changes are heterogeneous and also indicate the presence of areas with decreasing ozone concentrations. When anthropogenic emissions were increased to be consistent with the extensive urbanization in the greater NYC area, the O3 levels increased in outer counties of the metropolitan region but decreased in others, including coastal Connecticut and the Long Island Sound area.

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Resource Description

Climate Scenario :

specification of climate scenario (set of assumptions about future states related to climate)

Special Report on Emissions Scenarios (SRES)

Special Report on Emissions Scenarios (SRES) Scenario: SRES A2

Exposure : ☑

weather or climate related pathway by which climate change affects health

Air Pollution, Temperature, Other Exposure

Air Pollution: Interaction with Temperature, Ozone, Other Air Pollution

Air Pollution (other): NOx;VOC;CO;Isoprene

Temperature: Fluctuations

Other Exposure: water vapor

Geographic Feature: ☑

resource focuses on specific type of geography

Urban

Geographic Location: ☑

resource focuses on specific location

United States

Health Impact: ☑

specification of health effect or disease related to climate change exposure

Health Outcome Unspecified

Mitigation/Adaptation: ☑

mitigation or adaptation strategy is a focus of resource

Mitigation

Model/Methodology: ☑

type of model used or methodology development is a focus of resource

Exposure Change Prediction

Resource Type: ☑

format or standard characteristic of resource

Research Article

Timescale: ☑

time period studied

Medium-Term (10-50 years)